PTO 07-6903

CC = JP
20020315
Kokai
14074870

ACTUATOR FOR FINE POSITIONING OF HEAD ELEMENT, HEAD GIMBAL ASSEMBLY EQUIPPED WITH SAID ACTUATOR, DISK DEVICE EQUIPPED WITH SAID HEAD GIMBAL ASSEMBLY, AND MANUFACTURING METHOD FOR SAID HEAD GIMBAL ASSEMBLY

[Heddo soshi no bisho ichikimeyo akuchiyueeta, gai akuchiyueeta o sonaeta heddo jinbaru asenburi, gai heddo jinbaru asenburi o sonaeta deiusku sochi oyobi gai heddo jinbaru asenburi no seizo hoho]

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UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. SEPTEMBER 2007
TRANSLATED BY: THE MCELROY TRANSLATION COMPANY

PUBLICATION COUNTRY	(19):	JP
DOCUMENT NUMBER	(11):	14074870
DOCUMENT KIND	(12):	Kokai
PUBLICATION DATE	(43):	20020315
APPLICATION NUMBER	(21):	12253930
APPLICATION DATE	(22):	20000824
INTERNATIONAL CLASSIFICATION[7]	(51):	G 11 B 21/10
		5/596
		21/21
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TITLE	(54):	ACTUATOR FOR FINE POSITIONING OF HEAD ELEMENT, HEAD GIMBAL ASSEMBLY EQUIPPED WITH SAID ACTUATOR, DISK DEVICE EQUIPPED WITH SAID HEAD GIMBAL ASSEMBLY, AND MANUFACTURING METHOD FOR SAID HEAD GIMBAL ASSEMBLY

FOREIGN TITLE [54A]: Heddo soshi no bisho ichikimeyo akuchiyueeta, gai akuchiyueeta o sonaeta heddo jinbaru asenburi, gai heddo jinbaru asenburi o sonaeta deiusku sochi oyobi gai heddo jinbaru asenburi no seizo hoho

Claims /12*

1. Actuator for fine positioning of head element characterized in that it is adhered to a head slider having at least one head element and a support mechanism, which is provided with a pair of movable arms that can be displaced in accordance with drive signals, wherein the aforementioned head slider is held between said movable arms. /13

2. The actuator described in Claim 1, characterized in that a base part is provided affixed to the aforementioned support mechanism, and the aforementioned movable arms project from said base part.

3. The actuator described in Claim 2, characterized in that it includes a slider affixing part whereby the side surface of the aforementioned head slider is adhered to the end of the aforementioned movable arms.

4. The actuator described in Claim 3 characterized in that it has a shape such that a gap is formed between the side surface of the aforementioned head slider and the aforementioned movable arms, excluding the aforementioned slider affixing part.

5. The actuator described in any one of Claims 2-4, characterized in that the aforementioned base part is formed from a ceramic sintered material that has elasticity.

6. The actuator described in any one of Claims 2-5, characterized in that the aforementioned movable arms are provided with an arm member made with a ceramic sintered material that has plasticity and a piezoelectric drive part formed on the side surface of said arm member.

7. The actuator described in Claim 5 or 6, characterized in that the aforementioned ceramic sintered material is ZrO_2.

8. The actuator described in any one of Claims 2-7, characterized in that the aforementioned movable arms are constituted to rock the aforementioned head slider in a straight line longitudinally in accordance with drive signals.

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* [Numbers in right margin indicate pagination of the original text.]

9. The actuator described in any one of Claims 2-8, characterized in that the inside corner where the aforementioned base part and the aforementioned movable arm are joined forms an obtuse angle or is smooth and flat.

10. The actuator described in any one of Claims 2-9, characterized in that the inside corner where the slider adhesion part which is furnished at the end of the aforementioned movable arms and to which the side surfaces of the aforementioned head slider are adhered, and the aforementioned movable arms are joined forms an obtuse angle or is smooth and flat.

11. The actuator described in any one of Claims 1-10, characterized in that the overall flat shape of the actuator is コ-shape.

12. The actuator described in any one of Claims 1-11, characterized in that it has a thickness of no more than the thickness of the head slider to be held.

13. The actuator described in any one of Claims 1-12, characterized in that the spacing between the ends of the aforementioned pair of movable arms is set somewhat smaller than the width of the head slider to be held.

14. The actuator described in any one of Claims 1-13, characterized in that the aforementioned head element is a thin-film magnetic head element.

15. A head gimbal assembly characterized in that it comprises the actuator for fine positioning described in any one of Claims 1-14, the aforementioned head slider held between the aforementioned pair of movable arms of said actuator, and the aforementioned support mechanism adhered to the aforementioned actuator.

16. The head gimbal assembly described in Claim 15, characterized in that the aforementioned movable arms of the aforementioned actuator and the aforementioned head slider are adhered with an adhesive.

17. The head gimbal assembly described in Claim 15 or 16, characterized in that the aforementioned actuator and the aforementioned support mechanism are adhered with adhesive and solder.

18. A disk device characterized in that it is equipped with at least one of the head gimbal assemblies described in any one of Claims 15-17.

19. Manufacturing method for a head gimbal assembly, characterized in that an actuator for head element fine positioning equipped with a pair of movable arms that can be displaced in accordance with a drive signal is prepared, a head slider that has at least one head element is held between the aforementioned movable arms of said actuator, and the aforementioned actuator to which said head slider is attached is adhered to a support mechanism.

20. The manufacturing method described in Claim 19, characterized in that the spacing between the ends of the aforementioned movable arms of the aforementioned actuator is set somewhat smaller than the width of the aforementioned head slider, and with the aforementioned holding, first, the aforementioned head slider is provisionally fixed by the gripping force of said movable arms.

21. The manufacturing method described in Claim 20, characterized in that after the aforementioned provisional fixing, the aforementioned actuator and the aforementioned head slider are finally fixed.

22. The manufacturing method described in any one of Claims 19-21, characterized in that the aforementioned actuator to which the aforementioned head slider is attached and the aforementioned support mechanism are fixed with adhesive or solder.

Detailed explanation of the invention /2

[0001]

Technical field of the invention

The present invention relates to an actuator for fine positioning of a head element, such as a thin-film magnetic head element or an optical head element, a head gimbal assembly (HGA) equipped with the actuator, a disk device equipped with the HGA, and an HGA manufacturing method.

[0002]

Prior art

With magnetic disk devices, the magnetic head slider attached to the end of the HGA suspension is made to float above the surface of a rotating magnetic disk, and in this state, recording to the magnetic disk and/or playback from the magnetic disk is performed with the thin-film magnetic head mounted on the magnetic head slider.

[0003]

In recent years, with larger capacity and higher density recording by magnetic disk devices, higher density in the disk radial orientation (track width orientation) has increased, and with the conventional control using only a voice coil motor (hereafter referred to as VCM), it has become difficult to accurately align the magnetic head position. /3

[0004]

One means of realizing precise positioning of magnetic heads that has been proposed is technology wherein an additional actuator mechanism is mounted more toward the magnetic slider from the

conventional VCM, and fine, precise positioning that is not tracked with a VCM is accomplished with the actuator (refer to Japanese Kokai Patent Application Nos. Hei 6[1994]-259905, Hei 6[1994]-309822, and Hei 8[1996]-180623, for example).

[0005]

The present applicant has proposed an actuator with a pickup structure as this type of actuator. The actuator with a pickup structure is made with one end fixed to a suspension, the other end fixed to the magnetic head slider, and a columnar displacement generating part that connects the ends integrally in an I shape with piezoelectric material using PZT, and the actuator and the magnetic head slider are attached in a stepped form above the suspension. In short, it is a built-up type cantilevered structure (beam held at one end) wherein the actuator is held between the suspension and the magnetic head slider.

[0006]

Problems to be solved by the invention

An HGA using an actuator with such a pickup structure (1) is a built-up structure, so that the HGA thickness of the magnetic head slider increases by the amount of the actuator, (2) the entire actuator is constituted with a piezoelectric material, such as PZT, which is a brittle material, and the actuator and magnetic head slider have a cantilevered structure that is built up in a stepped form, so that they are subject to 'impact but with very low impact resistance, (3) the stroke when moving for fine positioning may change, and a sufficient stroke may not be obtained, (4) it has a three-dimensional, complicated attachment structure, so that handling during assembly is very difficult, and productivity is very poor, since conventional HGA assembly devices cannot be used, (5) it must be assembled with a gap remaining between the magnetic head slider and the actuator, and between the actuator and the suspension so as not

to hinder the operation of the actuator. The fact that there are such problems not only further worsens impact resistance, but because the gap present during assembly must be constant, the assembly precision is lowered. It is especially difficult to keep the degree of parallelism of the suspension actuator and magnetic head slider correct, so that there are various problems, e.g., exacerbation of the head characteristics.

[0007]

Therefore, the present invention solves the problems of the prior art described above. Its objective is to provide an actuator for fine positioning of a head element with no increase in HGA thickness caused by actuator mounting, an HGA equipped with the actuator, a disk device equipped with the HGA, and an HGA manufacturing method.

[0008]

Another objective of the present invention is to provide an actuator for fine positioning of a head element wherein the impact resistance can be significantly improved, an HGA equipped with the actuator, a disk device equipped with the HGA, and an HGA manufacturing method.

[0009]

Still another objective of the present invention is to provide an actuator for fine positioning of a head element with which the HGA productivity can be significantly improved and improved quality can also be achieved, an HGA equipped with the actuator, a disk device equipped with the HGA, and an HGA manufacturing method.

[0010]

Means to solve the problems

With the present invention, an actuator for fine positioning of a head element is proposed, which is an actuator for fine positioning of a head element which is adhered to a head slider having at least one head element and a support mechanism; it is provided with a pair of movable arms that can be displaced in accordance with a drive signal, and is constituted so that the head slider is held between the movable arms.

[0011]

Since it is constituted so that the head slider is held between a pair of movable arms that can be displaced in accordance with a drive signal, even though an actuator is furnished, the problem of a commensurate increase in thickness of the HGA does not occur. For this reason, it is not necessary to change the dimensions of the magnetic disk device, etc., because of the actuator mounting. Also, since the actuator and the head slider do not have a cantilevered structure, the impact resistance is significantly improved. Furthermore, because a structure in which the head slider is held between movable arms is used, the ends of the movable arms that actually provide displacement are extended to the end of the head slider. For this reason, even when the dimensions of the head slider change, strokes of the same size as during fine positioning operation can be provided, so that sufficient strokes can be obtained.

[0012]

It is preferable that a base part affixed to a support mechanism be provided, and that the movable arms project from the base part.

[0013]

It is preferable that there be a slider adhesion part with which the side surfaces of the head slider are adhered to the ends of the movable arms.

[0014]

In this case, it is more preferable that there be a shape such that there is no gap between the side surfaces of the head slider and the movable arms, excluding the slider adhesion part.

[0015]

It is also preferable that the base part be formed from a ceramic sintered material that has elasticity. Additionally, it is more preferable that the movable arms be provided with an arm member using a /4
ceramic sintered material that has plasticity, and a piezoelectric drive part formed on the side surface of the arm member. The impact resistance of the actuator itself is improved by using a ceramic sintered material, such as ZrO_2, with high rigidity, as the principal part of the actuator.

[0016]

It is more preferable that the movable arms be constituted to rock the head slider in a straight line longitudinally in accordance with drive signals. Because linear rocking rather than angular rocking is used, more highly precise positioning of the head element is possible.

[0017]

It is also preferable that the inside corner where the base part and the movable arms are joined from an obtuse angle or be smooth and flat. It is also preferable that the inside corner where the head slider

adhesion part which is furnished at the ends of the movable arms and to which the side surface of the head slider is adhered, and the movable arms are joined form an obtuse angle or be smooth and flat. The impact resistance of the actuator itself is thereby significantly improved.

[0018]

It is also preferable that the overall planar shape of the actuator be approximately U-shaped.

[0019]

It is also preferable that the actuator have a thickness of no more than the thickness of the head slider to be held.

[0020]

It is preferable that the spacing between the ends of the pair of movable arms be set somewhat smaller than the thickness of the slider to be held.

[0021]

It is also preferable that the head element described above be a thin-film magnetic head element.

[0022]

With the present invention, additionally, an HGA is provided which is equipped with the actuator for fine positioning described above, a head slider held between the pair of movable arms of the actuator, and the aforementioned support mechanism adhered to the actuator.

[0023]

It is also preferable that the movable arms of the actuator and the head slider be adhered with an adhesive.

[0024]

It is also preferable that the actuator and the support mechanism be adhered with an adhesive and solder.

[0025]

A disk device which is equipped with at least one HGA described above is also provided by the present invention.

[0026]

An HGA manufacturing method is also provided by the present invention wherein an actuator for head element fine positioning, which is provided by a pair of movable arms that can be displaced in accordance with a drive signal, is prepared, a head slider that has at least one head element is held between the movable arms of the actuator, and the actuator to which the head slider is attached is adhered to a support mechanism.

[0027]

First, a head slider is affixed held between the movable arms of the actuator. Next, the composite body of the head slider and actuator is adhered to the support mechanism. Because the head slider is held between the movable arms of the actuator, the head slider and the actuator can be assembled on a flat plate,

so that positioning is easy, and high-precision positioning is possible. Furthermore, a heat-cured adhesive, which is not very fast acting but has satisfactory hardening characteristics, can be used as the adhesive, so that a high quality head slider and actuator composite body can be obtained. Additionally, the composite body can be mounted on the suspension applied to an HGA assembly device, so that productivity is very good, and manufacturing costs can be reduced.

[0028]

The spacing between the ends of the movable arms of the actuator is set to be somewhat smaller than the width of the head slider. For holding, first, it is preferable that the head slider be provisionally fixed by the gripping force of the movable arms. It can be thus provisionally fixed without using a holder or the like.

[0029]

After provisional fixing, it is preferable that the actuator and the head slider be finally fixed by curing of the adhesive.

[0030]

It is also preferable that the actuator to which the head slider is attached and the support mechanism be adhered with an adhesive or solder.

{0031]

Embodiment of the invention

Figure 1 is an oblique view that schematically shows the constitution of the major parts of a magnetic disk device as an embodiment of the present invention. Figure 2 is an oblique view representing an entire head gimbal assembly (HGA). Figure 3 and Figure 4 are oblique views of the end of the HGA in this embodiment viewed from different directions.

[0032]

In Figure 1, (10) represents mulendle magnetic disks that rotate about shaft (11), and (12) represents an assembly carriage device for positioning a magnetic head slider above a track. Assembly carriage device (12) is constituted primarily of a carriage (14) that can slide angularly centered on shaft (13), and a main actuator (15) composed of a voice coil motor (VCM), for example, that drives carriage (14) to slide angularly.

[0033]

The base parts of mulendle drive arms (16) stacked in the direction of shaft (13) are attached to carriage (14), and an HGA (17) is adhered to the end of each drive arm (16). Each HGA (17) is furnished at the end of a drive arm (16) so that a magnetic head slider furnished at the end will face the surface of a magnetic disk (10).

[0034]

As shown in Figures 2-4, the HGA is constituted with an actuator (22) for fine positioning, which holds the side surfaces of a magnetic head slider (21) that has a magnetic head element, which are adhered to the end of a suspension (20).

[0035]

Main actuator (15) shown in Figure 1 is furnished to displace drive arm (16) to which HGA (17) is attached and move the entire assembly, and actuator (22) is furnished to provide fine angular displacement cannot be performed by said main actuator (15).

[0036]

Suspension (20), as shown in Figures 2-4, is constituted primarily by first and second load beams (23) and (24), a hinge (25) that has elasticity and that connects first and second load beams (23) and (24) to each other, a flexure (26) that has elasticity and is supported adhered on second load beam (24) and hinge (25), and a disk-shaped base plate (27) furnished at the connection part (23a) of first load beam (23).

[0037]

Flexure (26) has a flexible tongue (26a), which is pressed against a dimple (not shown) furnished in second load beam (24), at one end. The base part (22a) of actuator (22) is adhered to tongue (26a) with an insulating layer (26b), made of polyimide or the like, interposed. Flexure (26) has elasticity so that magnetic head slider (21) is flexibly supported by tongue (26a) with actuator (22) interposed. Flexure (26), with this embodiment, is constituted with stainless steel sheet about 20 μm thick (SUS 304TA, for

example). Here, adhesion of flexure (26), second load beam (24) and hinge (25) is accomplished with pinpoint adhesion using mulendle weld points.

[0038]

Hinge (25) has elasticity in order to press slider (21) toward the magnetic on second load beam (24) with actuator (22) interposed. Hinge (25), in this embodiment, is constituted with stainless steel sheet about 40 μm thick.

[0039]

First load beam (23), in this embodiment, is constituted with stainless steel sheet about 100 μm thick, and supports hinge (25) over its entire surface. Here, adhesion of load beam (23) and hinge (25) is accomplished with pinpoint adhesion using mulendle weld points. Second load beam (24), in this embodiment, is also constituted with stainless steel sheet about 100 μm thick, and is adhered at the end to hinge (25). Here, adhesion of load beam (24) and hinge (25) is also accomplished with pinpoint adhesion using mulendle weld points. Moreover, at the end of second load beam (24), a lift tab (24a) is furnished to separate the HGA from the magnetic disk surface when non-operation.

[0040]

Base plate (27), in this embodiment, is constituted with stainless steel or iron about 150 μm thick, and is adhered by welding to attachment part (23a) at the base of first load beam (23). Base plate (27) is attached to drive arm (16) (Figure 1).

[0041]

A flexible wiring member (28) that includes mulendle lead conductors using a layered thin film pattern is formed or mounted on flexure (26). Wiring member (28) is formed with a known patterning method, like that used to manufacture a printed-circuit board on a thin metal sheet, such as a flexible printed circuit (FPC). Wiring member (28) is formed by laminating in order, starting with flexure (26), a first insulating material layer using a resin material, such as polyimide, about 5 μm thick, a patterned Cu layer (lead conductor layer) about 4 μm thick, and a second insulating material layer made using a resin material, such as polyimide, about 5 μm thick. Here, the portion of the connection pad for connecting to the magnetic head element, the actuator and external circuitry is formed by laminating an Au layer on a Cu layer, and an insulating material layer is not formed on top.

[0042]

Wiring member (28) in this embodiment is constituted by a first wiring member (28a) that includes 2 lead conductors in each side, with a total of 4 on both sides, connected to the magnetic head element, and a second wiring member (28b) that includes 1 lead conductor per side, for a total of 2 for both sides, connected to actuator (22).

[0043]

One end of the lead conductors of first wiring member (28a) are connected to a magnetic head element connection pad (29) furnished on separated part (26c) that is separated from flexure (26) and can move freely, at the end of flexure (26). Connection pad (29) is connected by gold bonding, wire bonding, stitch bonding or the like to terminal electrode (21a) of magnetic head slider (21). The other ends of the lead

conductors of first wiring member (28a) are connected to external circuitry connection pad (30) for connecting with external circuitry.

[0044]

One end of the lead conductors of second wiring member (28) are connected to actuator connection pad (31) formed on insulation layer (26b) of tongue (26a) of flexure (26), and connection pad (31) is connected to channel A and channel B signal terminal electrodes (22b) and (22c) furnished at base part (22a) of actuator (22). The other end of the lead conductors of second wiring member (28b) are connected to external circuitry connection pad (30) for connecting with external circuitry.

[0045]

It is clear that the structure of the suspension in the HGA in the present invention is not limited to the structure described above. However, although not shown, an IC chip for head driving could also be mounted along suspension (20).

[0046]

Figure 5 is a plan view showing an actuator structure in this embodiment. Figure 6 is a cross section showing the structure of the piezoelectric element of the actuator. Figure 7 is an oblique view for explaining the operation of the actuator.

[0047]

As shown in Figure 5, the plane shape of actuator (22) is approximately a square bracket shape, and a pair of movable arms (51) and (52) extend vertically from both ends of base part (50) (22a) adhered to the

suspension. At the ends of movable arms (51) and (52), slider adhesion parts (53) and (54) are respectively that are adhered to the side surfaces of magnetic head slider (21). The spacing between /6
slide adhesion parts (53) and (54) is set somewhat smaller than the width of the magnetic head slider to be held. The thickness of actuator (22) is set to no more than the thickness of the magnetic head slider to be held so as not to increase the thickness of the HGA by mounting of the actuator. In other words, by making the thickness of actuator (22) as large as the thickness of the magnetic head slider to be held, the strength of the actuator itself can be raised without increasing the thickness of the HGA.

[0048]

Slider adhesion parts (53) and (54) project toward magnetic head slider (21). Therefore, only these portions are adhered to the side surfaces of magnetic head slider (21), and the remaining portion will have a gap between the side surfaces of the magnetic head slider and movable arms (51) and (52).

[0049]

Movable arms (51) and (52) are constituted with arm members (51a) and (52a) and piezoelectric elements (51b) and (52b) formed on the side surfaces of arm members (51a) and (52a), respectively.

[0050]

Base part (50) and arm members (51a) and (52a) are formed integrally with a ceramic sintered material that has elasticity, ZrO_2, for example. By using a ceramic sintered material, such as ZrO_2, which is highly rigid, that is, bend-resistant for the main parts of the actuator, the impact resistance of the actuator itself is improved.

[0051]

Both piezoelectric elements (51b) and (52b), as shown in Figure 6, have a multilayer structure wherein a piezoelectric-electrostriction material layer (60) that expands and contracts using an inverse piezoelectric effect or electrostriction effect, a signal electrode layer (61), and a ground electrode layer (62) are alternately layered. Signal electrode layer (61) is connected to channel A or channel B signal terminal electrode (22b) or (22c) shown in Figures 3 and 4, and ground electrode layer (62) is connected to ground terminal (22d) or (22e).

[0052]

Piezoelectric-electrostriction material layer (60) is constituted with what is called a piezoelectric material, such as PZT, and normally undergoes polarization processing to improve displacement performance. The polarity orientation produced by the polarity treatment is the lamination orientation of the piezoelectric element. When the direction of the electric field when voltage is applied to an electrode layer agrees with the polarity orientation, the piezoelectric-electrostriction material layer between the two electrodes expands (piezoelectric longitudinal effect) in the thickness direction, and contracts (piezoelectric lateral effect) in the in-plane direction. On the other hand, when the electric field direction is opposite to the polarity orientation, the piezoelectric material layer contracts (piezoelectric longitudinal effect) in the thickness direction and expands (piezoelectric lateral effect) in the in-plane direction.

[0053]

When voltage that causes contraction or expansion is applied to piezoelectric elements (51b) and (52b), each piezoelectric element portion contracts or expands to a commensurate extent, and movable arms (51) and (52) flex in an S shape as shown in Figure 7 and their ends thereby rock in a straight line longitudinally.

The result is that magnetic head slide (21) also rocks in a straight line laterally in the same way. In this way, because the rocking is linear rather than angular, more highly precise positioning of the magnetic head element is possible.

[0054]

A voltage could also be applied simultaneously to both piezoelectric elements so that mutually opposite displacement occurs. That is, an alternating voltage could be applied simultaneously to both piezoelectric elements so that when one expands, the other contracts, and when one contracts, the other expands. Rocking of the movable arms in this case will be centered at the position when no voltage is applied. In this case, the rocking amplitude when the drive voltage is the same will be about twice that when voltage is applied alternately. However, in this case, at one side of the rocking, the piezoelectric element will expand, and the drive voltage in this case will be the reverse of the polarity direction. For this reason, when the applied voltage is high, or when it is applied continuously, there is the risk of attenuating the polarity of the piezoelectric-electrostriction material. Therefore, by adding a constant DC bias voltage in the same direction as the polarity and using the alternating voltage described above superimposed on the bias voltage as drive current, the direction of the drive voltage will not be the reverse of the direction of polarity. Rocking in this case will be centered at the position as when only bias voltage is applied.

[0055]

Here, piezoelectric-electrostriction material means a material that expands or contracts due to reverse piezoelectric effect or an electrostriction effect. The piezoelectric-electrostriction material may be any material that can be applied to the displacement generating part of the actuator as described above, but

ceramic piezoelectric-electrostriction materials such as PZT [Pb(Zr, Ti)O_3], PT ($PbTiO_3$), PLZT [(Pb, La)(Zr, Ti)O_3], barium titanate ($BaTiO_3$), and the like are normally preferred because of their high rigidity.

[0056]

Because actuator (22) in this embodiment is constituted in this way so that the side surfaces of magnetic head slider (21) are held between movable arms (51) and (52), the thickness of the HGA does not increase by that amount although actuator (22) is furnished. The composite body of actuator (22) and magnetic head slider (21) is not a cantilevered structure, so that impact resistance is also significantly improved. Furthermore, as a structure wherein magnetic head slider (21) is held between movable arms (51) and (52) is also used, so that the ends of movable arms (51) and (52) that actually provide displacement are extended to the end of magnetic head slider (21). For this reason, even when the dimensions of magnetic head slider (21) are changed, strokes of the same size as with fine positioning can be provided, so that the sufficient required strokes can be obtained.

[0057]

Figures 8-10 are oblique view that explain a part of the manufacturing process of the HGA in this embodiment.

[0058]

First, magnetic head slider (21) and actuator (22) are prepared. Magnetic head slider (21) is formed with a known manufacturing method. Actuator (22) is manufactured by forming a continuous /7
tubular-shaped block, one side surface of which is open and that has the U-shaped cross section as shown in Figure 5, for example, with a ceramic sintered material (ZrO_2, for example) that has elasticity, and after

forming a continuous piezoelectric element that has a cross section as shown in Figure 6 by printing on both side surfaces, it is cut into sections at the prescribed width and terminal electrodes, etc., are formed on it.

[0059]

As shown in Figure 8, first, both the adhesion parts on both sides surfaces of magnetic head slider (21) are coated with an adhesive (80), e.g., a thermally cured epoxy resin adhesive or the like. Magnetic head driver (21) is inserted between movable arms (51) and (52) of actuator (22) mounted on a flat plate (81) in the same way.

[0060]

The spacing (W_A) between slider adhesion parts (53) and (54) in movable arms (51) and (52) of actuator (22) is set to be somewhat smaller than width (Ws) of magnetic head slider (21), so that magnetic head slider (21) is provisionally fixed by the gripping force of movable arms (51) and (52) without using a holder or the like. Adhesive (80) is then heat cured to finally fix it.

[0061]

A composite body (82) of magnetic head slider (21) and actuator (22) is thereby formed.

[0062]

Since the assembly of magnetic head slider (21) and actuator (22) can be performed on a flat plate in this way, positioning is easy, and high-precision assembly is possible. Furthermore, because a heat-cured

adhesive that is slow acting but has very good hardening characteristics can be used as the adhesive, a high-quality head slider and actuator composite body (82) can be obtained.

[0063]

Next, as shown in Figure 9, composite body (82) of magnetic head slider (21) and actuator (22) is adhered on flexure (26) of suspension (20). In more concrete terms, insulation layer (26b) on tongue (26a) of flexure (26)) and separated part (26c) of flexure (26) are coated with adhesive (90) and (91), respectively, and base part (22a) (50) of actuator (22) of composite body (82) is adhered to insulation layer (26b), and the end of magnetic head slier (21) of composite body (82) is adhered to separated part (26c).

[0064]

Next, as shown in Figure 10 (A), actuator connection pad (31) and channel A and channel B signal terminal electrodes (22b) and (22c) of actuator (22), as well as ground connection pad (100) and ground electrode terminals (22d) and (22e) of actuator (22), are electrically connected with solder or a silver containing epoxy resin. If they are connected using solder, the connection strength between composite body (82) and the suspension is increased.

[0065]

As shown in Figure 10 (B), magnetic pad terminal connection pad (29) and terminal electrode (21a) of magnetic head slider (21) are the electrically connected using gold ball bonding, for example.

.[0066]

The adhesion and electrical connection of composite body (82) and the suspension described above using an adhesive can be implemented using an HGA assembly device, since composite body (82) has a simple shape. Because mounting using an HGA assembly device is possible in this way, productivity will be very good, and lowered manufacturing cost are possible.

[0067]

Figure 11 is a plan view showing the structure of an actuator in another embodiment of the present invention.

[0068]

As shown in the figure, the actuator has a planar shape that is approximately a U-shaped, and a pair of movable arms (111) and (112) extend vertically from both ends of base part (110) adhered to a suspension. Slider adhesion parts (113) and (114) that are adhered to the side surfaces of magnetic head slider (21) are furnished at the ends of movable arms (111) and (112).

[0069]

Slider adhesion parts (113) and (114) project toward magnetic head slider (21) and therefore only these portions are adhered to the side surfaces of magnetic head slider (21); in the remaining portion, there will be a gap between the magnetic head slider side surfaces and movable arms (111) and (112).

[0070]

Movable arms (111) and (112) are each constituted with arm members (111a) and (112a), and piezoelectric elements (111b) and (112b) formed on a side surface of arm members (111a) and (112a).

[0071]

Base part (110) and arm members (111a) and (112a) are formed integrally with a ceramic sintered material that has elasticity, ZrO_2, for example. By making the main parts of the actuator from a ceramic sintered material, such as ZrO_2, that has high rigidity, that is, is bend-resistant, the impact resistant of the actuator itself is improved.

[0072]

The structure and operation of piezoelectric elements (111b) and (112b) is the same as the actuator shown in Figure 5.

[0073]

In this embodiment, corner reinforcing parts (115)-(118) are formed integrally with the same ceramic sintered material as base part (110) and arm members (111a) and (112a) so that the inside corners where movable arms (111) and (112) and base part (110) are joined, and the inside corners where movable arms (111) and (112) and slider adhesion parts (113) and (114) are joined form, instead of a right angle, an obtuse angular or no angle. The impact resistance of the actuator itself is thereby improved.

[0074]

The constitution, function and effects of this embodiment are otherwise exactly the same as in the case of the application example in Figure 2, so that their explanation will be omitted.

[0075]

Figure 12 is a plan view showing the structure of an actuator in still another embodiment of the present invention.

[0076]

As shown in the figure, the actuator has a planar shape that is approximately a U-shaped, /8
and a pair of movable arms (121) and (122) extend vertically from both ends of base part (120), which is adhered to a suspension. Slider adhesion parts (123) and (124) that are adhered to the side surfaces of magnetic head slider (21) are furnished at the ends of movable arms (121) and (122), respectively.

[0077]

Slider adhesion parts (123) and (124) project toward magnetic head slider (21). Therefore only these portions are adhered to the side surfaces of magnetic head slider (21), so that there will be a gap in the remaining part between the magnetic head slider side surfaces and movable arms (121) and (122).

[0078]

Movable arms (121) and (122) are constituted with arm members (121a) and (122a), and piezoelectric elements (121b) and (122b) formed on a side surface of arm members (121a) and (122a).

[0079]

Base part (120) and arm members (121a) and (122a) are formed integrally with a ceramic sintered material that has elasticity, such as ZrO_2. By making the main parts of the actuator from a ceramic sintered material, such as ZrO_2, which is highly rigid, that is, is bend-resistant, the impact resistant of the actuator itself is improved.

[0080]

The structure and operation of piezoelectric elements (121b) and (122b) are the same as the actuator shown in Figure 5.

[0081]

In this embodiment, corner reinforcing parts (125)-(128) are formed integrally with the same ceramic sintered material as base part (120) and arm members (121a) and (122a) so that the inside corners where movable arms (121) and (122) and base part (120) are joined, and the inside corners where movable arms (121) and (122) and slider adhesion parts (123) and (124) are joined form, instead of right angles, a smooth, flat surface. The impact resistance of the actuator itself is thereby improved.

[0082]

The constitution, function and effects of this embodiment are otherwise exactly the same as those of the embodiment in Figure 2, so that their explanation will be omitted.

[0083]

Figure 13 is a plan view showing the structure of an actuator of still another embodiment of the present invention.

[0084]

As shown in the figure, the actuator has a planar shape that is approximately a U-shaped, and a pair of movable arms (131) and (132) extend vertically from both ends of base part (130), which is adhered to a suspension. Slider adhesion parts (133) and (134) that are adhered to the side surfaces of magnetic head slider (21) are furnished at the ends of movable arms (131) and (132), respectively.

[0085]

Slider adhesion parts (133) and (134) project toward magnetic head slider (21). Therefore only these portions are adhered to the side surfaces of magnetic head slider (21) and there will be a gap in the remaining part between the magnetic head slider side surfaces and movable arms (131) and (132).

[0086]

Movable arms (131) and (132) are constituted with arm members (131a) and (132a), and piezoelectric elements (131b) and (132b) formed on a side surface of arm members (131a) and (132a).

[0087]

Base part (130) and arm members (131a) and (132a) are formed integrally with a ceramic sintered material that has elasticity, such as ZrO_2. By making the main parts of the actuator from a ceramic sintered

material, such as ZrO_2, that is highly rigid, that is, is bend-resistant, the impact resistant of the actuator itself is improved.

[0088]

The structure and operation of piezoelectric elements (131b) and (132b) are the same as the actuator shown in Figure 5.

[0089]

In this embodiment, corner reinforcing parts (135)-(138) are formed integrally with an epoxy resin in the inside corners where movable arms (131) and (132) and base part (130) are joined, and the inside corners where movable arms (131) and (132) and slider adhesion parts (133) and (134) are joined. The impact resistance of the actuator itself is thereby improved.

[0090]

The constitution, function and effects of this embodiment are otherwise exactly the same as those of the embodiment in Figure 2, so that their explanation will be omitted.

[0091]

Above, the present invention was explained using an actuator for fine positioning of a thin-film magnetic head element and an HGA equipped with the actuator, but the present invention is not limited to such an actuator and can be applied to an actuator for fine positioning of a head element other than a thin-film magnetic head element, for example, an optical head element, and to an HGA equipped with the actuator.

[0092]

The embodiments described above all show illustrative examples of the present invention and do not imply limitations. The present invention can be implemented with various variations and modifications. Therefore, the scope of protection of the present invention is defined only by the patent claims and the equivalent range.

[0093]

Effects of the invention

As explained in detail above, with the present invention, an actuator is constituted so that the head slider is held between a pair of movable arms that can be displaced in accordance with drive signals, so that the problem of a commensurate increase in thickness of the HGA does not occur even though an actuator is provided. For this reason, it is not necessary to change to the dimensions of the magnetic disk device due to the mounting of the actuator, etc. Also, because the actuator and head slider do not have a cantilevered structure, the impact resistance is significantly improved. Furthermore, because s structure wherein the head slider is held between movable arms is used, the ends of the movable arms, which actually provide displacement, will be extended to the end of the head slider. For this reason, even when the dimensions of the head slider change, strokes of the same size as during fine positioning operation can be provided, so that sufficient required strokes can be obtained. /9

[0094]

In addition, with the present invention, as the HGA manufacturing method, first, a head slider is fixed held between the movable arms of the actuator, and the head slider and actuator composite body is adhered

to a support mechanism. Because the head slider is held between the movable arms of the actuator, assembly of the head slider and the actuator can be performed on a flat plate, so that positioning is easy, and high-precision assembly is possible. Furthermore, because a heat-curable adhesive that is not fast acting but has very good hardening characteristics can be used as the adhesive, a high-quality head slider and actuator composite body can be obtained. In addition, because the composite body can be mounted on a suspension applied to an HGA assembly device, productivity is very good, and lowered manufacturing costs are possible.

Brief description of the figures

Figure 1 is an oblique view that schematically shows the constitution of the major parts of a magnetic disk device, as an embodiment of the present invention.

Figure 2 is an oblique view representing the entire HGA in the embodiment in Figure 1.

Figure 3 is an oblique view of the end of the HGA in the embodiment in Figure 1.

Figure 4 is an oblique view of the end of the HGA in the embodiment in Figure 1 viewed from a different direction than Figure 3.

Figure 5 is a plan view showing the structure of the actuator in the embodiment in Figure 1.

Figure 6 is a cross section showing the structure of the piezoelectric element portion of the actuator in Figure 5.

Figure 7 is an oblique view for explaining the operation of the actuator in Figure 5.

Figure 8 is an oblique view explaining a part of the manufacturing process of the HGA in the embodiment in Figure 1.

Figure 9 is an oblique view explaining a part of the manufacturing process of the HGA in the embodiment in Figure 1.

Figure 10 an oblique view explaining a part of the manufacturing process of the HGA in the embodiment in Figure 1.

Figure 11 is a plan view showing the structure of the actuator in another embodiment of the present invention.

Figure 12 is a plan view showing the structure of the actuator in still another embodiment of the present invention.

Figure 13 is a plan view showing the structure of the actuator in yet another embodiment of the present invention.

Explanation of symbols

10	Magnetic disk
11, 13	Shaft
12	Assembly carriage device
14	Carriage
15	Main actuator
16	Drive arm
17	HGA
20	Suspension
21	Magnet head slider
21a	Terminal electrode
22	Actuator
22a, 50	Base part
22b, 22c	Signal terminal electrode

22d, 22e	Ground terminal electrode
23	First load beam
23a	Attachment part
24	Second load beam
24a	Lift tab
25	Hinge
26	Flexure
26a	Tongue
26b	Insulation layer
26c	Separated part
27	Base plate
28	Wiring member
28a	First wiring member
28b	Second wiring member
29	Magnetic head element connection pad
30	External circuitry connection pad
31	Actuator connection pad
(51), (52), (111), (112), (121), (122), (131), (132)	Movable arm
(51a), (52a), (111a), (112a), (121a), (122a), (131a), (132a)	Arm member
(51b), (52b), (111b), (112b), (121b), (122b, (131b), (132b)	Piezoelectric elemen t
(53), (54), (113),(114), (123), (124), (133), (134)	Slider adhesion part
(60)	Piezoelectric-electrostriction material layer
(61)	Signal electrode layer

(62)	Ground electrode layer
(80), (90), (91)	Adhesive
(81)	Flat plate
(82)	Composite body
100	Ground connection pad
(115), (116), (117), (118), (125), (126), (127), (128), (135), (136), (137), (138)	Corner reinforcing part

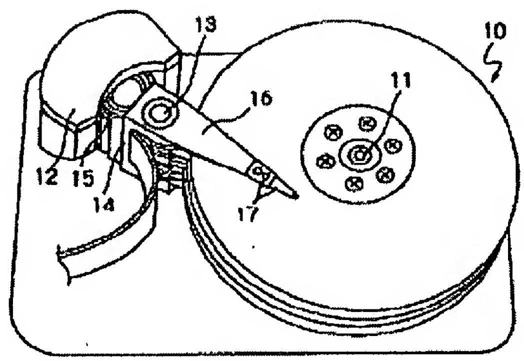

Figure 1

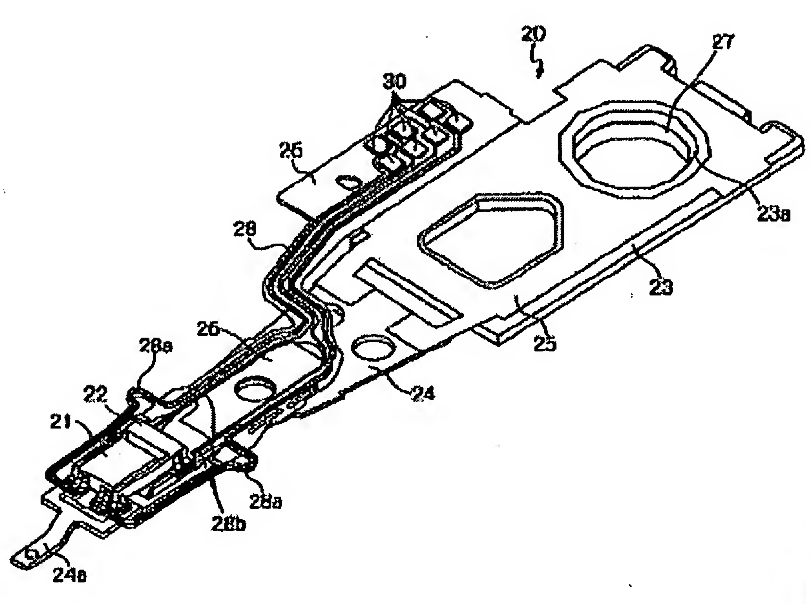

Figure 2

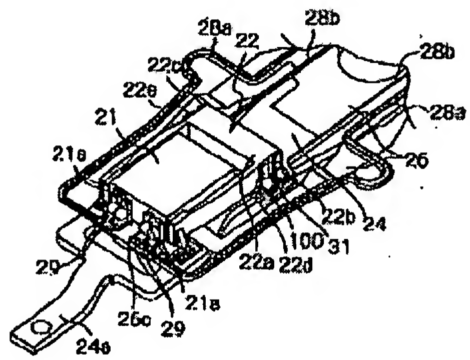

Figure 3

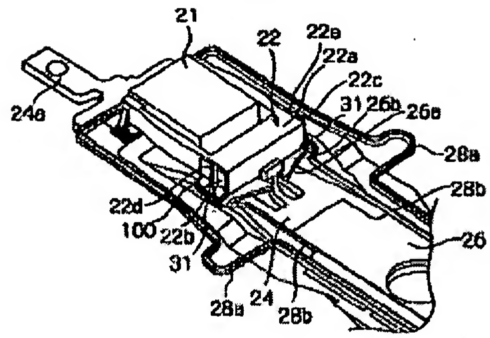

Figure 4

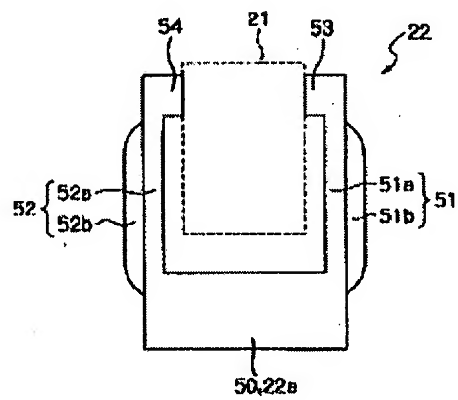

Figure 5

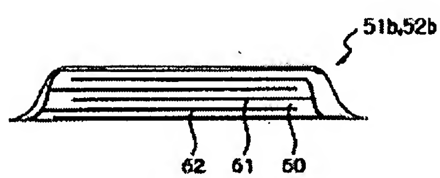

Figure 6

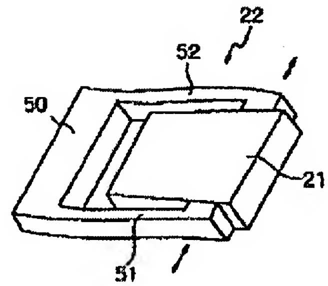

Figure 7

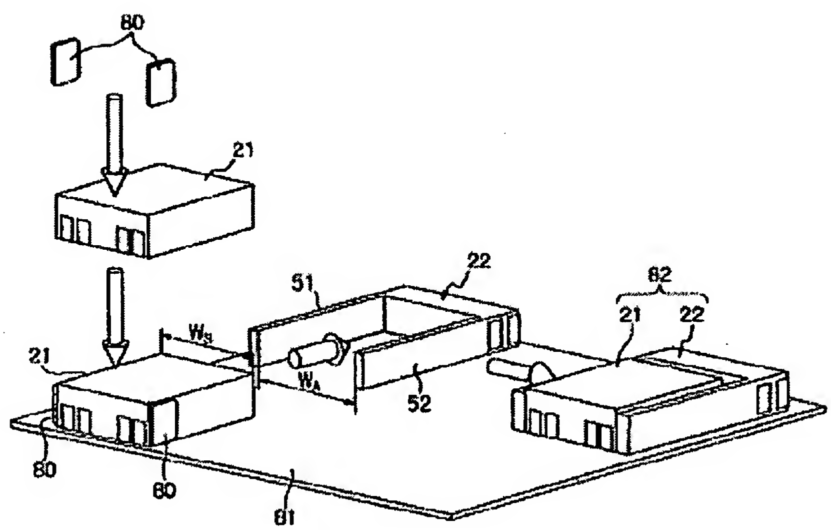

Figure 8

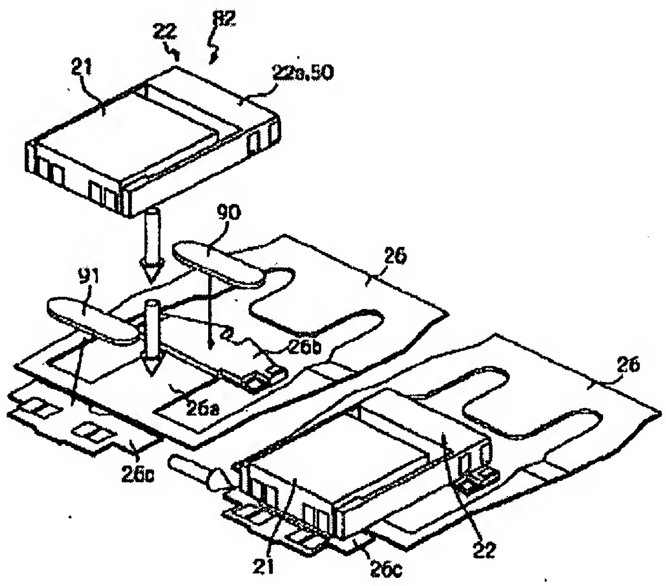

Figure 9

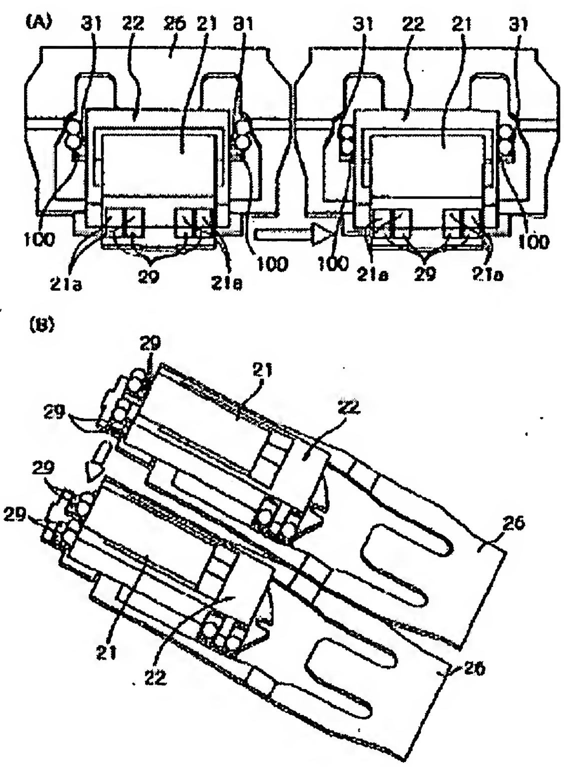

Figure 10

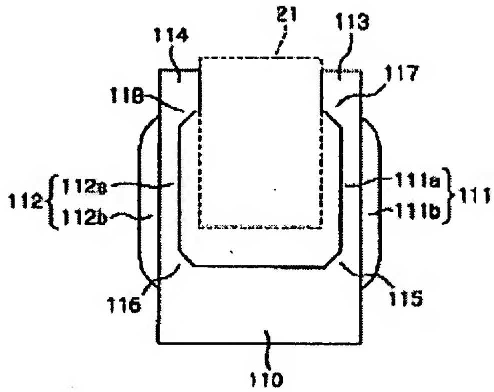

Figure 11

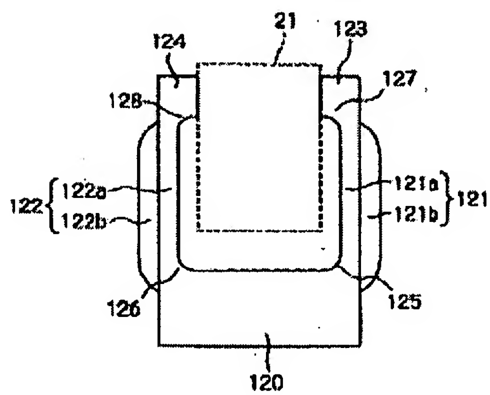

Figure 12

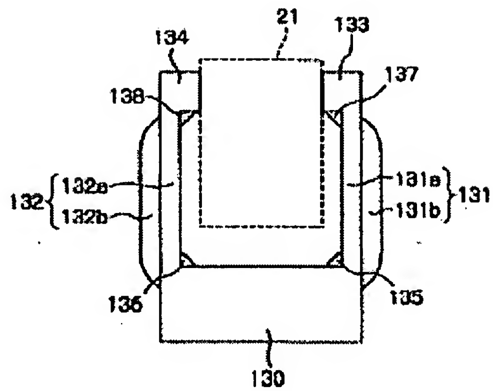

Figure 13